DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY2008.A STTR Proposal Submission

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the fiscal year (FY) 2008 STTR solicitation (FY2008.A). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology" and may be subject to ITAR restrictions. If you plan to employ NON-U.S. Citizens in the performance of a DARPA STTR contract, please inform the Contracting Officer who is negotiating your contract. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers.

ALL PROPOSAL SUBMISSIONS TO DARPA MUST BE SUBMITTED ELECTRONICALLY THRU WWW.DODSBIR.NET.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST, 19 March 2008 deadline.** If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

Acceptable Format for On-Line Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Cost Proposal information should be provided by completing the on-line Cost Proposal form. This itemized listing should be placed as the last page(s) of the Technical Proposal Upload. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.)

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk.

DARPA recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and slows down the system. DARPA will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of March, you will receive an e-mail acknowledging receipt of your proposal.

PLEASE DO NOT ENCRYPT OR PASSWORD PROTECT TECHNICAL PROPOSAL

HELPFUL HINTS:
1. Consider the file size of the technical proposal to allow sufficient time for uploading.
2. Perform a virus check.
3. Signature is no longer required at the time of submission.
4. Submit a new/updated Company Commercialization Report.
5. Please call the Toll Free SBIR Help Desk if you have submission problems: 866-724-7457
6. DARPA will not accept proposal submissions by electronic facsimile (fax) or email.

Additional DARPA requirements:

- DARPA Phase I awards will be Firm Fixed Price contracts.
- **If you collaborate with a University, please highlight the research that they are doing and verify that the work is FUNDAMENTAL RESEARCH.**
- Phase I proposals **shall not exceed $99,000,** and may range from 8 to 12 months in duration. Phase I contracts cannot be extended.

- DARPA Phase II proposals must be invited by the respective Phase I DARPA Program Manager. Phase 2 invitations will be based on the technical results reflected in the Phase I contract and/or final reports as evaluated by the DARPA Program Manager utilizing the criteria in Section 4.3. DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-227-2423 or Internet: http://www.ccr.gov.

The responsibility for implementing DARPA's Small Business Technology Transfer (STTR) Program rests with the Contracts Management Office. The DARPA SBIR/STTR Program Manager is Connie Jacobs, see address below. DARPA invites small businesses, in cooperation with a researcher from a university, an eligible contractor-operated federally funded research and development center (FFRDC), or a non-profit research institution, to submit proposals thru the DoD website www.dodsbir.net/submission.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: CMO/SBIR/STTR
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Home Page http://www.darpa.mil

STTR proposals submitted to DARPA will be processed by DARPA and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I - page 7), twice the weight of the other two evaluation criteria. PLEASE NOTE THAT MANY OF THE WEAKEST PROPOSALS SCORED LOW ON EVALUATION CRITERIA "C" "THE POTENTIAL FOR COMMERCIAL (GOVERNMENT OR PRIVATE SECTOR) APPLICATION AND THE BENEFITS EXPECTED TO ACCRUE FROM THIS COMMERCIALIZATION. DARPA IS PARTICULARLY INTERESTED IN THE POTENTIAL TRANSITION OF STTR RESULTS TO THE U.S. MILITARY, AND EXPECTS EXPLICIT TREATMENT OF A TRANSITION VISION IN THE COMMERCIALIZATION-STRATEGY PART OF THE PROPOSAL. THAT VISION SHOULD INCLUDE IDENTIFICATION OF THE PROBLEM OR NEED IN THE DEPARTMENT OF DEFENSE THAT THE STTR RESULTS WOULD ADDRESS, A DESCRIPTION OF HOW WIDE-SPREAD AND SIGNIFICANT THE PROBLEM OR NEED IS, AND IDENTIFICATION OF THE POTENTIAL END-USERS (ARMY, NAVY, AF, SOCOM, ETC) WHO WOULD LIKELY USE THE RESULTS. THE SMALL BUSINESS MUST DEMONSTRATE UNDERSTANDING OF THE END USE OF THEIR EFFORT AND THE END USERS.

ALL SELECTION/NON-SELECTION LETTERS WILL BE SENT TO THE PERSON LISTED AS THE "CORPORATE OFFICIAL" ON THE PROPOSAL.

As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.

- **Successful offerors will be expected to begin work no later than 30 days after contract award.**

- For planning purposes, the contract award process is normally completed with 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

DARPA STTR 08.A Topic Index

DARPA STTR 08.A Topic Descriptions

ST081-001 TITLE: Advanced Development for Defense Science and Technology

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: N/A

OBJECTIVE: Identify and develop innovative technology in the Physical, Engineering, and Life Sciences for enabling defense technology.

DESCRIPTION: Novel technology which relies on innovations in science and engineering has provided a critical advantage to our national defense. To this end, DSO is soliciting proposals for advanced technology development in a variety of enabling technical areas which include:
* Application and development of advanced mathematics for DoD applications.
* New and innovative approaches to biosensor technology and biological technology for maintaining the warfighters performance, capabilities and survival in battlefield conditions.
* Remote interrogation and control of biological systems at the system/organ/tissue/cellular/molecular scales.
* Novel interface and sensor designs for interacting with the central (cortical and subcortical structures) and peripheral nervous systems, with a particular emphasis on non-invasive and/or non-contact approaches.
* New technologies for understanding and predicting the behavior of individuals and groups, especially those that elucidate the neurobiological basis of behavior and decision making.
* New technology for training individuals and teams, including embedded training and simulation; technologies which lead to understanding and improving team performance; and new approaches to improve rapid decision-making in chaotic or data-poor environments.
* Technologies to enable interrogation and control of biological systems at the system/organ/tissue/cellular/modecular scales.
* New technologies to drastically reduce the logistics burden of medical treatment in the field.
* Advanced signal processing techniques for the decoding of neural signals in real time, specifically those associated with operationally relevant cognitive events, including target detection, errors, and other decision-making processes.

PHASE I: Conduct a feasibility study which would investigate and define the proposed idea or device and its feasibility.

PHASE II: Develop the research and technology advances and methods identified in Phase I to demonstrate a proof-of-concept prototype.

PHASE III DUAL USE APPLICATIONS: The technology developed under this STTR will be used in military and civilian commercial sector.

REFERENCES:
1. http://www.dod.mil/ddre/mainpage.htm

2. http://www.dod.mil/ddre/scitech.htm

3. http://ostp.gov/html/m06-17.pdf

KEYWORDS: Sensor Array, Biotechnology, Novel Materials, Embedded Training, Decision Making, Neural Signal Analysis

ST081-002 TITLE: Novel Neural-Electrical Interfaces for Neural Device Control

TECHNOLOGY AREAS: Electronics, Human Systems

ACQUISITION PROGRAM: N/A

OBJECTIVE: The growing field of neural engineering provides a variety of solutions for the chronically ill. Epilepsy and Parkinson's patients are treated through deep brain stimulation, a process which mediates their dysfunction through electrical impulses delivered via electrode. Paralysis victims are able to control computer cursors in two-dimensional space with their thoughts, and in some cases experience restored function in motor systems from electrical stimulation controlled by neural impulses. Research from primates indicates the ability to manipulate external robotic arms by tapping into the portion of the brain which controls biological arm movement. Cochlear implants restore hearing to the deaf, and work continues on addressing restoration of vision through prostheses4. Current electrodes for neural recording are designed for research in primates, not for medical applications in humans. Those that are designed with humans in mind are generally limited in number of channels and relatively untested in terms of long term stability of recording. Further, the means to transmit large quantities of data requires percutaneous wiring, creating the possibility of infection at the implant site8.

DESCRIPTION: Neural devices have great potential to provide severely injured warfighters restorative capabilities by allowing a natural, near-biologic means of controlling external devices1. However, such devices require high-fidelity neural signal provided by different cortices of the brain2. In addition, devices which seek to restore sensory function, such as visual and auditory prostheses, as well as proprioception and tactile sense in the case of motor prostheses, must be capable of stimulating over long periods of time in a reliably reproducible manner3.

However, long-term recording and stimulation over modern neural-electrical interfaces is made difficult by biological responses to implanted devices. A layer of scar tissue often begins to surround recording devices as a result of the insertion of electrodes and mechanical deviations to the recording systems5,6. In addition, components of the systems can break due to perturbations resulting from natural movement or sudden shock, requiring re-implantation7.

Advances in neural-electrical interfaces would provide a stronger platform for research as well as a necessary enabling technology for medical applications. With interfaces that remain biologically stable and functional over the long-term, warfighters would have access to a broad range of naturally controlled devices that would restore lost function through electrical stimulation or robotic assistance.

PHASE I: Prepare a feasibility study for a neural-electrical interface concept. During the first phase, the performer will propose a conceptual interface and a preliminary design. A report will be generated. As part of the final report, plans for Phase II will be proposed.

PHASE II: Develop a prototype based on the preliminary design from Phase I. All appropriate engineering testing and clinical validation in acute and chronic phases will be performed. A critical design review will be performed to finalize the design and prototype units will be manufactured and tested.

PHASE III DUAL USE APPLICATIONS: There is both a military and commercial application for this technology in biomedical applications for restorative prostheses and implanted neural devices. Longer lasting interfaces will provide more robust, high fidelity control of peripheral devices such as prosthetic limbs in amputees or assistive electrical stimulation systems in stroke and paralysis patients. This technology also enables the application of neural engineering to a variety of other problems including rehabilitation in Parkinson's and epilepsy patients, as well as those suffering loss of function from traumatic injury.

REFERENCES:
1. Lebedev, M.A. and M.A. Nicolelis. "Brain-machine interfaces: past, present and future," Trends in Neuroscience, 29 (9): 536-46, September 2006.

2. Schwartz, A.B. "Cortical neural prosthetics," Annual Review of Neuroscience, 27: 487-507, 2004.

3. McCreery D.B., Yuen T.G., and L.A. Bullara. "Chronic microstimulation in the feline ventral cochlear nucleus: physiologic and histologic effects," Hearing Research, 149 (1-2), 223-38, November 2000.

4. Humayun, M.S. et al. "Visual perception in a blind subject with a chronic microelectronic retinal prosthesis," Vision Research, 43 (24): 2573-81, November 2003.

5. Griffith R.W. and D.R. Humphrey. "Long-term gliosis around chronically implanted platinum electrodes in the Rhesus macaque motor cortex," Neuroscience Letters, 406 (1-2): 81-6, October 2006.

6. Biran R., Martin, D.C., and P.A. Tresco. "Neuronal cell loss accompanies the brain tissue response to chronically implanted silicon microelectrode arrays," Experimental Neurology, 195 (1): 115-26, September 2005.

7. Subbaroyan, J., Martin, D.C., and D.R. Kipke. "A finite-element model of the mechanical effects of implantable microelectrodes in the cerebral cortex," Journal of Neural Engineering, 2 (4): 103-13, December 2005.

8. Staecker, H., Chow, H., and J.B. Nadol Jr. "Osteomyelitis, lateral sinus thrombosis, and temporal lobe infarction caused by infection of a percutaneous cochlear implant," American Journal of Otology, 20 (6): 726-8, November 1999.

KEYWORDS: Electrodes, Interfaces, Neural, Cortical, Materials

ST081-003 TITLE: Early Detection of Infectious Disease Outbreak

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: N/A

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop novel technologies that will provide early detection and identification of potential biological outbreaks (either natural or as a result of bioterrorism) by monitoring circulating double stranded DNA (dsDNAs). Detection, including sample preparation, should be rapid and require less than 1.5 hours. Sensitivity should allow for $\leq$30 ng of starting material to allow diagnosis of large populations that may have been exposed to a biological outbreak or attack.

DESCRIPTION: Current methods for diagnosing infection by biological agents require observing the progression of clinical symptoms or other labor-intensive bioassays. If an outbreak or attack were to occur on a large scale, hospitals and clinics would be overrun with patients seeking diagnosis and treatment. Thus, there is a need for the earliest detection of infection. During the infectious cycle, dsDNA from both viruses and bacteria are degraded by the host and released. These circulating dsDNA fragments could then serve as a specific biomarker of infection. For example, detection of cell-free DNA from rabbits infected with Candida albicans was used to monitor disease progression.1 However, it is unclear if DNA detection occurs prior to the observation of symptoms. The detection of human herpesvirus-6 DNA in the plasma of asymptomatic individuals with repressed disease suggests this technique may also allow detection at very early stages of infection.2 The current effort would determine if dsDNA levels can be used as markers for diagnosis of infectious disease (bacteria/viral). These markers must be detectable using less than or equal to 30 ng of starting material (total dsDNA in sample plasma, tears, fluids, saliva, etc) and the assay should require no more than one and one-half hours to complete from sample to result. The development of this system would allow for immediate testing of any individuals suspected of coming in contact with the biological agent or infected individuals in order to decrease the impact of an outbreak or attack.

PHASE I: Prepare feasibility study for dsDNA detection and identification as a result of infectious disease. During the first phase, the performer will develop an assay to determine if dsDNAs can be used to identify infection from an infectious disease agent. Identification should occur within 1.5 hours and require ≤30 ng starting dsDNA material. As part of the final report, plans for Phase II will be proposed.

PHASE II: Phase II will develop a prototype instrument that can be manufactured and distributed to military and civilian health care providers for use in hospitals or areas of troop deployment.

PHASE III DUAL USE APPLICATIONS: There is dual use application of this technology in both military and commercial health care. An enemy could use biological weapons on deployed troops or as an attack on a civilian population. Outbreaks in either scenario would benefit from pre-symptom diagnosis and identification of infectious agent exposure.

REFERENCES:
1. Kasai, M., et. al. "Use of quantitative real-time PCR to study the kinetics of extracellular DNA released from Candida albicans, with implications for diagnosis of invasive Candidiasis," Journal of Clinical Microbiology, Vol. 44, p. 143-150, 2006.

2. Achour, A., et. al. "Human herpesvirus-6 (HHV-6) DNA in plasma relfects the presence of infected blood cells rather than circulating viral particles," Journal of Clinical Virology, Vol. 38, pp. 280-285, 2007.

KEYWORDS: nucleic acids, infectious disease, biological weapon, early diagnosis, manufacturing

ST081-004 TITLE: <u>Probabilistic Logic for Knowledge Representation and Automated Reasoning</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: N/A

OBJECTIVE: Military operations require plans that are logical, but are based upon knowledge of culture, actions, and consequences that are uncertain. In the civilian world, many agencies, organizations and businesses also require rational plans, and likewise may have uncertainties with respect to clients, markets and resources. The objective is to develop an inference engine that exploits knowledge captured both in terms of probabilistic statements and logical relations (e.g., implications) to optimally combine reason about, and exploit the most important forms of captured knowledge. This inference capability should lead to more informed planning and operational activities in both military and civilian settings.

DESCRIPTION: Advanced artificial intelligence and related cognitive systems depend on techniques from mathematics and computer science to represent knowledge and reason about complex, imprecise, and uncertain situations. Probability theory and the various forms of mathematical logic hold great promise in this regard, as knowledge represented in terms of probabilities and logical statements can be manipulated and exploited by rigorous-derived automated reasoning algorithms and architectures. The opportunity has recently arisen (cf. [1]-[5]) to integrate these two fundamental knowledge paradigms to yield robust, flexible, and scalable reasoning capabilities that greatly exceed those currently available.

Our objective is to exploit the advantages of the hybrid representation, learning and inference power of probabilistic and logical systems combined. Probabilities allow one to express and draw inferences in cases when the fact(s) is uncertain rather than just T or F. Logic allows one to express very powerful inference rules simply and modularly. The synergies by combining each approach in principled ways should yield inference systems that are significantly more robust than systems based on logic or probability alone.

PHASE I: Develop a detailed system concept and initial design feasibility study for a hybrid representation system that both learns and reasons. Identify and characterize the integrated logical and probabilistic modeling, learning and inference capabilities required to fully implement the system, and define the approach to be used to develop them. Identify thresholds of subsystem capability that translate into thresholds of system-level capability—especially prior knowledge, system scale-up and approximate computation techniques. Define performance metrics for the system.

PHASE II: Develop a complete demonstration system and demonstrate performance in scenarios relevant to challenges experienced by decisionmakers.

PHASE III DUAL USE APPLICATIONS: Probabilistic logic has important applications in military command and control scenarios where information that is known to be factual needs to be integrated with information that is uncertain. An example of this would be a decision aid that is intended to predict the outcome of an engagement that uses as input information that is known, such as the composition, location, readiness, etc., of U.S. and allied forces, plus information that is measured or estimated, such as the composition, location, readiness, etc. of opposing forces, and information that is predicted, such as the weather. Scenarios in which it is necessary to integrate factual and uncertain information abound in the private sector as well, for example logistics planning (fleet availability/carrying capacity, customer demand, and weather), economics (plant capacity, consumer demand, competition and market forces), and political/social science (geography, population characteristics, human events). This technology can be commercialized by industry for use with management information systems as well as military command and control applications.

REFERENCES:
1. A. Shirazi, E. Amir, “Probabilistic Modal Logic,” 22nd National Conference on Artificial Intelligence (AAAI"07), 2007.

2. P. Domingos, M Richardson “Markov Logic Networks.” Machine Learning, 62, 107-136, 2006.

3. B. Milch, B. Marthi, S. Russell, D. Sontag, D. Ong, and A. Kolobov. (2005) "BLOG: Probabilistic Models with Unknown Objects". Proc. 19th International Joint Conference on Artificial Intelligence (IJCAI): 1352-1359.

4. U. Nodelman, D. Koller, and C.R. Shelton (2005). "Expectation Propagation for Continuous Time Bayesian Networks." Proceedings of the Twenty-first Conference on Uncertainty in AI (UAI) (pp. 431-440).

5. C. Sutton, A. McCallum and K. Rohanimanesh. “Dynamic Conditional Random Fields.” Journal of Machine Learning Research (JMLR), Vol. 8 (Mar), pages 693-723, 2007.

KEYWORDS: Cognitive Systems, Bayes, Logic, Artificial Intelligence

ST081-005 TITLE: Algorithms for Detecting Imminent Collisions

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: N/A

OBJECTIVE: Develop algorithms for deciding whether or not an approaching object is on a collision course, using realistic models for sensor error.

DESCRIPTION: One of the most vital perception tasks for a vehicle navigating in a dynamic environment is to (i) detect objects which may be on a collision course, and (ii) to decide which threats will result in collisions versus misses. Based on these decisions, the vehicle may plan an evasive maneuver, or take an action to mitigate the severity of the collision. In order to take such actions, the perception system must predict the collision with sufficient lead time for the evasive action to be planned and executed. This required lead time can be several seconds, such as the case of a UAV planning and executing an evasive maneuver to avoid another high-speed aircraft. At such long lead times, the hazard object is quite distant, and estimates of its range and trajectory have significant measurement errors. As a result, the False Alarm Rate (FAR) and/or False Negative Rate (FNR) (Type I and Type II errors) of the decision system are usually unacceptably high. The problem is exacerbated when the host or the hazard vehicle is not traveling in a straight line.

Many traditional approaches to this problem are based on estimating the threat object’s trajectory using a Kalman Filter. Inputs to the Kalman Filter are measurements of range and azimuth to the threat made using onboard sensors.

However, in many cases, the noise distributions of the sensors violate the underlying assumptions of Kalman Filter Theory. As a result, the performance of the decision rules in terms of FAR and FNR cannot be modeled well. This makes them dangerous to deploy in real systems.

The field of Statistical Decision Theory focuses on how to make decisions based on noisy measurements in such a way as to minimize the FAR and/or FNR. Much of this theory uses knowledge of the sensor's noise distribution to formulate decision rules with predictable performance levels (i.e. predictable False Alarm and False Negative rates). See [1], for example. However, this theory has not yet been applied to the area of collision prediction for ground and air vehicles.

This STTR topic is focused on designing decision algorithms for predicting collisions among realistic vehicles with realistic sensors. In particular, we are interested in vehicles with on-board sensors for detecting and tracking incoming vehicles. Examples of such sensors include cameras, RADAR, and LADAR. The host vehicle's own size and motion may be assumed to be known. A collision is defined as any incursion into a safety region around the host vehicle.

The desired outcome of this work is an algorithm for deciding whether or not a collision will occur, based on measurements of features of the incoming threat, such as azimuth, range, size, and/or rate of looming. The algorithm should be robust to a variety of measurement noise distributions. In particular, the algorithm should use realistic models for the noise distributions of the features that are being measured. This topic is NOT focused on designing the sensor-processing algorithms for measuring these features.

PHASE I: Feasibility study to design algorithms for differentiating imminent collisions from near-hits. Compute FAR and FNR using realistic noise distributions. Compare theoretical FAR and FNR with empirical results from Monte Carlo simulations. Analyze the sensitivity of the performance to changes in noise distributions.

PHASE II: Based on the results of Phase I, select which features of the incoming threat are most important to measure, and with what accuracy. Design a sensor suite and sensor processing algorithms to measure those features. Build a prototype system, and demonstrate the feasibility of the concept on real data.

PHASE III DUAL USE APPLICATIONS: A successful approach will have significant impact on a number of areas. For example, this algorithm will be useful for autonomous ground robots operating in dynamic environments. UAVs need such decision rules in order to operate in the National AirSpace alongside piloted aircraft (the Sense-And-Avoid problem). In the commercial automotive world, these algorithms could be used to trigger active safety systems such as selt-belt pre-tensioners, and airbags which deploy before the collision for enhanced protection of the driver.

REFERENCES:
1. James O. Berger, Statistical Decision Theory and Bayesian Analysis. Second Edition. 1980. Springer Series in Statistics. ISBN 0-387-96098-8.

KEYWORDS: Statistic Decision Theory, Sense And Avoid, Collision Detection, Sensor Processing

ST081-006 TITLE: <u>Universal Self-Supervising Hierarchical Learning</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: N/A

OBJECTIVE: Prepare a Phase I feasibility study for implementing cutting-edge hierarchical learning algorithms that are self-supervising while learning and are applicable to very broad – universal – classes of problems. While traditional AI and neural network research has produced approaches and architectures that can be tuned to specific problems or specific inputs, the focus here is on algorithms that are universal and massively scalable. Universal is to be taken in the sense that the algorithms will start with little domain knowledge, but employ significant unsupervised or self-supervised learning to incrementally acquire appropriate hierarchical representations and feature spaces for any problem with which they are presented. Massively scalable means the algorithms support very rich connection models and huge input sets. Unlike algorithms in commercial use today these algorithms would learn new representation spaces and use them to improve learning itself toward ever more complex behaviors. This is in sharp contract to nearly all commercial learning systems today, which operate with a specified set of features.

DESCRIPTION: There is growing evidence (e.g., Hawkins, 2004, Granger, 2006) that much of specialized human knowledge and even specialized structures of human brain could actually be constructed from a very small set of thalamic-cortical algorithms, and that the acquisition of these structures is self-directed over a large period of experiential learning to reflect the structure inherent in the world as presented by our senses. If such a universal algorithm exists, many variants likely also exist, some of which may be much more appropriate for implementation in silicon. For example, O'Reilly (2006) contends that mechanisms fundamental to computers, such as bistable activation states and dynamic gating mechanisms are sufficient to satisfy the active maintenance and rapid updating of information observed in the prefrontal cortex. This STTR is seeking proposals that identify and ultimately implement the best of these variants. Proposals are expected to have a strong research component at a level suitable for generating publications in top-tier journals.

Ideal learning algorithms will be:

- General – applicable to a broad variety of domains without requiring tweaking and customization
- Knowledge free – No prior knowledge about domains will be required by the algorithms in order to learn
- Hierarchical – outputs from one level of the algorithm will be among the inputs to other levels. A system having this capability which is exposed to tasks in some higher level representation, would eventually learn to learn and learn to perform on that class of tasks as well as it would have performed assuming its native representation had be specifically designed for that higher class of tasks. (Notice, a system that fully realizes this objective can bootstrap toward any capability by iteratively building on prior learning.)
- Massively scaled – capable of leveraging massive computational cycles and massive inputs to iteratively "home in" on effective representations even when presented with poor starting representations for a problem.

Highly desirable characteristics of the algorithms include:

- Temporal – able to learn from sequential patterns in inputs
- Relational – able to represent and generalize over relational structures that cannot be represented in a strictly vector-of-features representation.
- Embedded learner – a learning system capable of both perceiving and affecting the target universe in a way that it can drive its own learning—e.g. self-supervised learning.

While the goal is a universal learning algorithm, proposals should specify a small number of specific domains (greater than one) that will be investigated. They should address the nature of pre-processing of the sensor data that will be required before presentation to the universal learning algorithm.

PHASE I: Conduct a feasibility study that addresses the boundaries and limits of generality of the proposed research and articulates a path forward for development and testing. This study should discuss how an implemented system will function without prior knowledge, what sorts of non-universal processing will be required before data is presented to the "universal learner," and support for the proposed approach drawn from the literature and/or empirical data. Plans for Phase II will be proposed as part of the final report.

PHASE II: Formal design of the algorithm(s) will be performed and a preliminary design review and report will be generated. All appropriate engineering testing and validation of identified design issues will be performed. A critical design review will be performed to finalize the design and a prototype unit will be built and tested.

PHASE III DUAL USE APPLICATIONS:
There are both military and commercial applications of this technology in information processing and knowledge acquisition. In particular, this technology would be suitable for any application that requires the acquisition of a complex representation that reflects a problem domain in the real world. For DoD this would include the broad range of autonomous systems; mission planning and mission assessment; decision aids for command and control; and data exploitation/information extraction from intelligence, surveillance, and reconnaissance systems. Examples

of commercial applications include machine vision for manufacturing, robotics, office automation, medical diagnostics (e.g., radiographic analysis, automated triage, etc.), and forensic analysis.

REFERENCES:
1. Hawkins, J., Blakeslee, S., On Intelligence, Times Books, 2004.

2. Granger R., "Engines of the Brain: The computational instruction set of human cognition." AI Magazine 27 (2006): 15-32.

3. Coen, M., "Multimodal Dynamics: Self-Supervised Learning in Perceptual and Motor Systems." Ph.D. Dissertation. Massachusetts Institute of Technology. 2006 (http://people.csail.mit.edu/mhcoen/Thesis/PhD.pdf).

4. Kowtha, V., Satyanarayana, P., Granger, R., and Stenger, D. (1994). Learning and classification in a noisy environment by a simulated cortical network. Proc. Third Ann. Comp. Neural Systems Conf., Boston: Kluwer, pp. 245-250.

5. O'Reilly, R.C. (2006). Biologically-Based Computational Models of High-Level Cognition. Science, 314, 91-94.

6. Biologically-Inspired Cognitive Architectures (BICA) program, http://www.arpa.mil/ipto/programs/bica/index.htm

7. Bootstrapped Learning (BL) program, http://www.darpa.mil/ipto/programs/bl/index.htm

KEYWORDS: Self-supervised learning, Cortical algorithms, Machine learning, Hierarchical learning, Active learning

ST081-007 TITLE: Wide Area Video Motion Blur Elimination

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: N/A

OBJECTIVE: Identify and develop methods to eliminate the effects of motion blur on wide area video, in particular the motion blur induced by the movement of a wide area video sensor during the pixel integration time.

DESCRIPTION: Wide area Electro-Optic video sensors are being developed that are capable of imaging very wide fields of view (>50 degree field of view) at frame rates exceeding 10 frames per second. There are a number of factors that go into determining the quality of imagery produced by a wide area sensor, in particular, the movement of the sensor during the "sensor exposure" time – the integration time of a pixel. The amount of motion induced pixel blur can be explicitly computed by knowing the velocity of the platform, the behavior of the system (usually a gimbal) where the sensor is mounted, and the integration time of a pixel. For example, if the total field of view of the wide field of view sensor is 60 degrees, the platform is moving at 50 meters per second, the pixel integration time is 6 milliseconds, and the sensor is center of the field of view with the sensor stabilized so that there is no pixel blur at the center of the field of view, then the pixel blur due to the movement of the aircraft during the pixel integration time will be about one pixel assuming that the pixel ground space distance is 10 centimeters. DARPA is seeking computationally efficient methods to eliminate motion blur induced by the movement of the sensor during the pixel integration time. It is expected that the sensor of interest will have an Inertial Measurement Unit (IMU) integrated with a Global Positioning System (GPS) receiver giving approximate position of the sensor. An example of the type of wide area system/sensor is the Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) being developed by DARPA. Information describing ARGUS-IS can be found at: http://dtsn.darpa.mil/ixo/solicitations.asp#0723

PHASE I: Feasibility study to identify an approach/algorithms that will reduce/eliminate pixel blur caused by the motion of the sensor during the pixel integration time. Show the results of the proposed approach, in a laboratory setting, on wide area imagery. Determine the computational complexity of the proposed approach and show how the approach will scale to sensors with more than a gigapixel.

PHASE II: Implement the algorithms developed during phase I in a real-time system that will be capable of processing sensor data with frames as large as 2 gigapixels running at a minimum of 10 frames per second.

PHASE III DUAL USE APPLICATIONS: The elimination of motion blur has military applications for aerial video photography as well as potential homeland security applications. The improvement in image quality by the elimination of motion blur via image processing techniques also has potential applications for photographic applications from ground based moving vehicles.

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KEYWORDS: Image Blur, Video, Sensor Stabilization

ST081-008 TITLE: Dynamic Multisensor Exploitation (DYME)

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: N/A

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Prepare a Phase I feasibility study to develop and verify algorithms utilizing detection inputs from multiple sensor modalities (Radar, Electro-Optic, Acoustic, etc) to discriminate between mobile combatants and vehicles in both an urban and littoral environment.

DESCRIPTION: Military Threats in the Global War on Terrorism (GWOT) use deceptive techniques to deny discovery by reconnaissance and surveillance sensors. These techniques vary from utilizing camouflage and concealment, to deceptive operation within civilian population and environments. The discovery of military threats is especially difficult in the urban terrain with obscuration by buildings and other structures, and in the littoral regions with foliage and river/shallow water concealment. The adversary's techniques and procedures are derived to deny, through hide and irregular movement, the current sensors' ability to consistently detect, track and identify their presence.

Multiple sensor data exploitation has been useful in defeating camouflage, concealment and deception when the threats are stationary, and the multiple sensors can efficiently detect target features to reduce the false classification of threat types. These techniques have not been demonstrated for small threats (dismounts and vehicles) in difficult environments, and when the threats are mobile. New technologies are needed to project the detection and discrimination of threat observables from each individual sensor modality, into consistent spatial and temporal conditions, where the features provide an improvement in discrimination of threats from cultural and civilian objects.

Processing of data from multiple sensors requires the ability to detect potential threats, extract the relevant features, and communicate the data to a sensor correlation and exploitation process. Architectures for multiple sensor exploitation must consider the amount of data collection, the distributed implementation of the correlation and tracking algorithms, and use of additional conditions within the environment (obscuration, weather, tactics, etc.) affecting the correct classification of threats. A key metric will be the computational cost of multiple sensor exploitation processing and requirements on data storage and dissemination.

Demonstration of the multiple sensor correlation for correct discovery of mobile threats must be accomplished by a combination of modeling and simulation, and validation with data collected in a representative environment. The research should specify the conditions and instrumentation on any future collection to insure successful verification of proposed algorithmic approaches.

PHASE I: Prepare a feasibility study for developing multiple sensor detection and identification of mobile threats in urban/littoral environments. During the first phase, the performer will propose advanced algorithms for combining complementary features on threats, where the multiple sensors are at dissimilar modalities, viewing geometries and times. As part of the final report, plans for Phase II will be proposed.

PHASE II: Formal design of the algorithmic implementation will be performed, and a preliminary design review and report will be generated. The design will be verified by a combination of modeling and simulation and limited experimental collections. Critical measures of Performance will be verified in terms of sensor characteristics, data quality and dissemination, and probability of correct classification of mobile asymmetric threats. A critical design review will be performing to finalize the design and a prototype processing unit will be designed and tested.

PHASE III DUAL USE APPLICATIONS: Candidate applications for this technology span both the military and commercial arenas. Application of the technology to current Tasking, Collection, Processing, Exploitation and Dissemination (TCPED) systems is most important. Application to Homeland Defense and commercial security applications are important extensions.

REFERENCES:
1. NetTrack Program: http://dtsn.darpa.mil/ixo/programs.asp?id=98

KEYWORDS: Multiple Sensor Exploitation, Camouflage Concealment & Deception, Modeling and Simulation

ST081-009 TITLE: Building Labels for Urban Environments (BLUE)

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: N/A

OBJECTIVE: Research and develop technologies enabling automated labeling of urban buildings by function type from surveillance video data.

DESCRIPTION: Urban areas include many buildings of various types: hotels, stores, offices, apartments, fire stations, hospitals, restaurants, places of worship, etc. In most cases, the proper classification of a building as an instance of one (or more) of a type is a matter of function more than form. The difference between an apartment building and an office building, for example, may not be obvious from its visual features alone. This poses a significant technical challenge for automated object recognition systems, which exploit patterns of visual features in still images.

DARPA seeks innovative approaches that exploits surveillance video data to classify buildings automatically. In addition to visual feature data such as color and line orientation, video captures data concerning motion over time. The latter affords the opportunity for automated recognition of patterns in moving objects in the vicinity of buildings. These motion patterns may be reliable indicators of a building's function. BLUE technology should be able to learn patterns that distinguish building types and to process video from surveillance video data, such as that collected from high-endurance military UAV platforms, to label buildings correctly.

Proposed research in the initial phase of this effort should focus on demonstrating, in a rigorously empirical and quantitative fashion, the capability of the offeror's technical approach. Offerors must clearly indicate the data sources they propose to use for development and testing, the building classes on which will they will concentrate, and metrics they will use to measure accuracy. Offerors are encouraged to follow emerging standards in geospatial representation, such as the CityGML building classification taxonomy and GML/KML for overlay of building labels on geospatial images.

PHASE I: Feasibility study to investigate viability and design approaches for BLUE technology. Validate through experimentation. Evaluate potential benefit to military operations and commercial applications.

PHASE II: Apply Phase I results, data, and analysis to develop a prototype that demonstrates the efficacy of BLUE technology. Evaluate the performance of prototype through experimentation on operationally realistic data. Successful technical approaches may transition to the system developed on the DARPA Urban Reasoning and Geospatial Exploitation (URGENT) program.

PHASE III DUAL USE APPLICATIONS: BLUE technology will provide enhanced mapping capabilities for both military and commercial cartographic organizations.

REFERENCES:
1. CityGML, http://www.citygml.org/

KEYWORDS: Cartography, object recognition, video exploitation

ST081-010 TITLE: Combat Video Analysis Engine

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: N/A

OBJECTIVE: Develop new tools for activity analysis of combat aerial video collected for tactical military operations. These tools should leverage new methods in computer vision, machine learning and probabilistic models to detect and recognize complex threats and suspicious activities without identification of specific individuals.

DESCRIPTION: Although massive quantities of aerial and ground video are available from military operations, automatic analysis of this data is generally limited to detection and tracking of objects and simple event recognition. The challenges preventing the automated detection of activities include huge amounts of background clutter, handling fragmented tracks, large variations in activity configurations, and effectively representing a wide variety of activity models in a computable form. Furthermore, the algorithms must operate on low resolution video (greater than 10 cm per pixel) from which identification of individuals is not possible.

DARPA is seeking methods to detect threats against US forces that can overcome these challenges while processing full motion combat video in real time. Activities of interest should be detected without assuming that objects are identified or accurately tracked through the duration of the activities. Massive amounts of data should be rapidly filtered to focus resources on likely activity candidates early in the processing chain. Activity models should handle partial temporal ordering, variable numbers of objects, and significant variations in activity duration. Metadata from sensors, platform, and from mission plans should be exploited. Contextual data such as terrain models, 3D urban models, road networks, cultural metadata, observed traffic patterns and other information should be used to reduce false alarms and resolve ambiguity.

PHASE I: Develop activity model representation, and overall approach to scaling up to massive video streams of military significance. Perform initial feasibility studies to estimate the scalability and accuracy of the approach.

PHASE II: Develop and implement the complete system architecture. Compare with existing methods to demonstrate improvement over the state-of-the-art on large, realistic data sets. Develop an operational prototype, or integrate the developed tools into an existing government system.

PHASE III DUAL USE APPLICATIONS: Candidate applications of this technology span both military and commercial requirements. In general, the availability of image and video data is growing substantially. Commercially, the proliferation of security cameras for a variety of purposes, such as traffic monitoring, yields fertile territory for a technology which can support detection and analysis of activities of interest. This capability will support both post-event forensic analysis and monitoring of live feeds to give alerts on immediate activities of interest, such as an automobile accident. This capability also has applicability to other applications, such as web-based video searches and video-library searches.

REFERENCES:
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5. N. Dimitrova, H. Zhang, B. Shahraray, I. Sezan, T. Huang, and A. Zakhor, “Applications of video content analysis and retrieval,” IEEE Multimedia, vol. 9, no. 3, pp. 42-55, July–Sept. 2002.

6. Digital Video Retrieval at NIST, http://www-nlpir.nist.gov/projects/t01v/

KEYWORDS: content-based video indexing and retrieval, content-based image indexing and retrieval, content-based multimedia indexing and retrieval, activity-based video indexing and retrieval, intelligent retrieval of surveillance video, similarity-based video retrieval, activity recognition, search by example

ST081-011 TITLE: High-Speed Diagnostic of Temperature and Intensity Variation on Diode-Laser Facets

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: N/A

OBJECTIVE: Develop a technique to detect rapid instabilities, on a time scale ranging from nanoseconds to microseconds, in the temperature and optical field intensity that can lead to degradation of the laser facet and to the device failure. The detection technique must be sufficiently rapid and sensitive so that remedial action suppressing these variations can be taken.

DESCRIPTION: Spatially localized high temperature and high optical intensity fluctuations on the facets of individual diode lasers and laser bars are associated with device degradation and eventual failure. These fluctuations, occurring on multiple time scales must be rapidly detected and mitigated in order to prevent runaway degradation of the laser and failure. A system for rapid detection of such variations will protect the laser by suppressing fluctuations that are detrimental to device operation.

PHASE I: Feasibility study to develop a technique to detect temperature and intensity variations on a diode facet with adequate temporal response and spatial resolution to support a power supply modification that can suppress variations that are detrimental to device reliability. Correlating these fluctuations with other transients to minimize false positives is highly desirable.

PHASE II: Fabricate a system that uses the technique developed in Phase I to demonstrate increased diode-laser performance and lifetime.

PHASE III DUAL USE APPLICATIONS: Laser-diode systems incorporating the high-speed diagnostic technique and remedial action to suppress variations detrimental to device operation will increase device performance. They will be invaluable to both military and commercial laser-diode systems that demand high performance and long life.

REFERENCES:
1. Todoroki, Sawai and Aiki, "Temperature distribution along the striped active region in high-power GaAlAs visible lasers," J. Appl. Phys. 58(3), pp.1124-1128), 1985.

2. Puchert, Barwolff, Menzel, Lau, Voss and Elsaesser, "Facet and bulk heating of GaAs/AlGaAs high-power laser arrays studied in spatially resolved emission and micro-Raman experiments, J. Appl. Phys. 80(10), pp. 5559-5563, 1996.

3. Sanayeh, Brick, Schmid, Mayer, Muller, Reufer, Streubel, Tomm, and Bacher, "Temperature-power dependence of catastrophic optical damage in AlGaInP laser diodes," Appl. Phys. Lett. 91 (041115), 2007.

KEYWORDS: high power laser diode, laser facet, reliability, materials/processes

ST081-012 TITLE: Microresonator-Based Active Silicon WDM-Modulator

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: N/A

OBJECTIVE: Simulate, design, and fabricate silicon microresonators to directly modulate wavelength division multiplexed (WDM) channels without the use of additional demultiplexers and multiplexers. The microresonator based modulators should have sufficiently large free spectral range (i.e. small diameter) to operate upon a single WMD channel without interfering with other channels. Each WDM signal would see only its specific modulator, bypassing the others which are not resonant with that wavelength, and therefore encounter low loss. The ability to provide either phase or amplitude modulation, or a controlled combination of the two, would be highly desirable.

DESCRIPTION: Wavelength division multiplexing allows simultaneous transmission of multiple signals through the same optical fiber or the same free space link. Current WDM systems employ multiple photonics devices within a single channel, including multiplexers (mux) and demultiplexers (demux). The silicon microresonator has shown potential for use in different device functions within the overall photonic system, from a laser source, modulator, filter, to a wavelength selective detector. This program calls for novel microresonator based devices that combine the demux and mux filter functions together with the modulation capability creating a device that can modulate a single channel of a WDM system while exposed to the entire multi-channel WDM signal. Applications may include the integration of a series of such demux/modulate/mux devices combined with a multi-wavelength laser source that generates a comb of unmodulated WDM channels. These devices must have direct voltage or current modulation capabilities. Designs capable of taking advantage of complex modulation format are of interest to this program. Proposers should include a clear link between design goals and potential system applications, and should include simulations validating the chosen approach.

PHASE I: Feasibility study to define and model novel microresonator based demux/modulate/mux devices that integrate the required WDM functionality. Simulate WDM system behavior that takes advantage of the novel microresonator based devices.

PHASE II: Fabricate the novel silicon based active microresonator devices and validate performance through extensive testing at the device and system levels. Produce fully packaged parts as deliverables for this program. Provide system level demonstrations showing improved performance due to novel devices.

PHASE III DUAL USE APPLICATIONS: Devices from this program will find applications in a wide range of military and civilian systems, taking advantage of WDM capabilities for communications and signal processing. Applications include digital and analog WDM systems for fiber and free space communications, with distances ranging from chip to chip and rack to rack through intercontinental fiber optic and global satellite communication systems. Integration with silicon electronics and additional silicon photonics devices will provide sophisticated WDM subsystems for use in a variety of signal processing and communications systems, including massively parallel multi-channel systems such as phased array systems.

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1. Alexander W. Fang, Richard Jones, Hyundai Park, Oded Cohen, Omri Raday, Mario J. Paniccia, and John E. Bowers, "Integrated AlGaInAs-silicon evanescent race track laser and photodetector",Optics Express, Vol. 15, Issue 5, pp. 2315-2322 (2007).

2. Qianfan Xu, Bradley Schmidt, Sameer Pradhan, Michal Lipson, "Micrometre-scale silicon electro-optic modulator", Nature 435, 325-327 (19 May 2005).

3. Xiaobo Xie, Jacob Khurgin, Jin Kang,Fow-Sen Choa, "Linearized Mach-Zehnder Intensity Modulator", IEEE PTL, vol. 15, no. 4, April 2003.

KEYWORDS: silicon microresonators, communications, interconnects, silicon photonics

ST081-013 TITLE: Front End Opto-Electronics for Future Radio Communications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: N/A

OBJECTIVE: Create and demonstrate new highly efficient RF photonic interconnection, integration and material engineering technologies that will greatly improve the performance capabilities of wideband military systems employing photonic technologies.

DESCRIPTION: Current DARPA programs such as ULTRA-T/R and PHOR-FRONT are addressing the need for new technologies that will help realize RF front-end architectures with improved performance and mission capabilities. These programs are addressing the need for advances in photonic devices such as efficient optical modulators and high power photodiodes as well as low noise figure and high spurious-free dynamic range RF photonic sub-systems and novel optical demodulation techniques. With the progress made in these programs at the device and sub-system level, an effort is now needed to advance the state of the art in RF photonic interconnection, integration and packaging technologies to realize highly efficient systems that also enable size, weight and power requirements to be reduced. The objective is to build on existing research efforts in order to further extend the performance of bi-directional RF front-ends interfaced with wideband antenna elements and RF photonic links. The goal of this topic is to advance antenna, RF and photonic circuit interconnection, integration and packaging technologies to meet the demanding performance requirements of military systems.

Sub-octave and multi-octave military transmit/receive systems will greatly benefit from new innovative approaches to wideband antenna, RF and photonic circuit integration and packaging that can significantly increase the efficiency of the interconnection between system elements and improve system performance. The previous gains made in developing novel devices for RF photonic sub-systems will be lost when trying to integrate these components without taking into consideration how the surrounding environment and packaging will impact the performance of the individual components. New material engineering and optical/RF interconnect and integration techniques are required to optimize the overall system performance with respect to receiver sensitivity and transmitter efficiency. In addition to efficient interconnections between the RF and photonic devices, new approaches to antenna design that lead to significant improvement in radiator efficiency are also required to optimize the efficiency of the entire antenna/RF/photonic path.

PHASE I: Feasibility and trade-off studies of new approaches for highly efficient integration and interconnection of antenna elements, RF components and photonic devices in military transmit/receive sub-systems incorporating photonic technologies. Determine the scalability of the efficient integration techniques to cover both sub-octave and multi-octave mission applications.

PHASE II: Proof of concept demonstration of the proposed highly efficient RF photonic interconnect technologies based on the Phase I feasibility study. Undertake suitable laboratory testing of the prototype system that demonstrates performance/sensitivity improvements in a relevant military sub-octave or multi-octave bi-directional transmit/receive system.

PHASE III DUAL USE APPLICATIONS: The new highly efficient antenna/RF/photonic integration approaches will be used in military radar, communication, and electronic warfare systems that incorporate photonic technologies. The technology would also find application in commercial systems such as wireless communication networks that employ fiber-optic antenna remoting.

REFERENCES:

1. http://www.darpa.mil/MTO/Programs/ultratr/index.html

2. http://www.darpa.mil/MTO/Programs/phorfront/index.html

3. D. Sievenpiper, L. Zhang, F. J. Broas, N. G. Alexopoulos and E. Yablonovitch, "High-impedance electromagnetic surface with a forbidden frequency band", IEEE Trans. Micro. Thy. & Tech., Vol. 47, No. 11, pp. 2059 – 2074, Nov. 1999.

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KEYWORDS: RF photonics, integration, efficient antennas, packaging, material engineering

ST081-014 TITLE: Small Low-Voltage Electro-Optic Modulators

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: N/A

OBJECTIVE: To demonstrate an external optical modulator with less than 100 millivolt drive voltage, more than 20 GHz electrical to electrical bandwidth, capable of transmitting more than 100 milliwatts and occupies less than 0.1 cc, unpackaged.

DESCRIPTION: External modulators are key components for fiber optic links, delay lines, transmitters and signal processing. Broadband links with gain is possible using very low drive voltage modulators that can transmit high optical powers. In these regards modulators with sub volt, preferably less than 100 millivolt, drive voltage that can transmit more than 100 milliwatts of optical power are highly desirable. Furthermore impedance of the modulator electrode should be as close to the 50 ohms which eliminates impedance matching issues and reduces the return loss. Electrical to electrical modulation bandwidths in excess of 20 GHz is essential. Moreover, if a broadband modulator driver could be easily integrated with the modulator, further advantages such as linearization, could be obtained. If such a device can be combined with a high power laser and a high power linear photodetector, a linear broadband microwave fiber optic link with gain is realized. At present, there is not an existing technology that can deliver such a modulator.

Compound semiconductor electro-optic modulators offer several advantages. Compound semiconductors have low electro-optic coefficients but have high refractive indices that show very little dispersion from microwave to optical frequencies. High refractive index improves electro-optic efficiency and low index dispersion allows traveling wave devices using the loaded line approach. Modulators in such materials also benefit from advanced device processing techniques. Such techniques allow the fabrication of highly confined electro-optically active optical nanowires. A tightly confined optical mode overlapping very well with externally applied electric fields can create very efficient electro-optic modulation. Modulator driver integration can also be realized using the appropriate material design.

PHASE I: Prepare a feasibility study of such a modulator. Design a material structure and optical waveguide that allow very efficient modulation. Propose a process for fabrication. As part of the final report, plans for Phase II will be proposed.

PHASE II: Fabricate the designed modulator, test the transfer function and determine the drive voltage. Compare with the design. If necessary design, fabricate and test again. Test power handling capability. Design a high speed version using the loaded line approach. Fabricate and characterize the electrode alone. Finally demonstrate a low voltage high speed modulator combining the electrode design with the optical design.

PHASE III DUAL USE APPLICATIONS: The new highly efficient modulators will be used in military radar, communication, and electronic warfare systems that incorporate broadband photonic technologies. The technology would also find application in commercial systems such as fiber-optic networks and telecommunications, where photonic integration offers compelling advantages over board-level processing.

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KEYWORDS: electro-optic modulator, fiber optic links, compound semiconductor, fabrication

ST081-015 TITLE: Transparent Organic Electronics for Displays and Spatial Light Modulators (SLM)

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: N/A

OBJECTIVE: Identify and develop innovative materials and methods for the manufacture of transparent organic electronics on glass substrates suitable for transparent displays and spatial light modulators.

DESCRIPTION: The development of transparent electronics would enable a number of revolutionary applications such as transparent displays and spatial light modulators (SLM)1. Currently transparent displays are produced by projecting the image onto the display's surface using either standard display technology or a laser raster. In the former case it is relatively bulky while in the latter case the colors and image complexity is limited. In addition both techniques scale poorly with the size of the display.

Research on organic semiconductors have advanced to the point that they equal the electronic properties of amorphous silicon.2. In addition they can be applied using scalable solution deposition techniques. Due to their relatively large band gap, many of the state-of-the-art organic materials are transparent to visible light. Current research is focused on improving the current carrier mobility but other electronic properties necessary for display and SLM applications (such as current density and switching voltage) have been less well explored.3. Solution manufacturing methods have also been developed for organic electronics but either the materials used have been very poor or when high performance organic semiconductors have been deposited only single transistors have been made.4.

Extension of the solution manufacturing techniques to the large scale deposition and patterning of high performance organic semiconductors will allow for the pixel control electronics necessary for high resolution transparent displays and SLMs. Simple integration of the control electronics with existing active materials will complete the production of the transparent devices.

PHASE I: Feasibility study to identify organic materials that have the potential to be deposited in a high throughput manner onto glass and which have the requisite electronic properties to drive display and SLM devices.

PHASE II: Develop the materials and integrate into a manufacturing processing for making electronic devices on glass and demonstrate a proof-of-concept array.

PHASE III DUAL USE APPLICATIONS: The technology developed under this STTR can be used in military and civilian commercial transparent display systems such as heads up displays, aircraft canopies, vehicle windows and visor displays. It can also be used in telescope systems that require compact, low cost aberration correction.

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KEYWORDS: Organic semiconductor, Transparent display, materials/processes